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AVIATION WEATHER HAZARDS

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The primary object of an airways weather service is to insure the safety of flight. It has other purposes, admittedly, but they are secondary. This does not mean that they are for that reason to be neglected or that any effort should be spared to accomplish them. It does mean, however, that the personnel of an airways weather service should never lose sight of the primary object of the service, which is to insure the immunity of passengers, pilots, and equipment against any and all accidents arising from or attributable to untoward weather on the airways or in the area over which they have supervision or for which they are responsible for advices. This fact being admitted it is pertinent to inquire (1) what the relation of weather in general is to the safety of flight, and (2) what conditions of weather preeminently militate against it.

The answer to question (1) may seem so self-evident to some that to offer it is to exhaust the obvious. Nevertheless it is not equally evident to all, and ignorance on this point sometimes prevails in quarters where it is least to be expected and where its existence constitutes a menace to safe flying operations. The personnel of an airways weather service should be in no doubt at all in regard to it; indeed, they should be so thoroughly informed on the subject as to feel no diffidence in asserting and maintaining the facts even in the face of doubt or contradiction from pilots or operators whose inexperience may lead them to discount weather hazards. Among the experienced there will always be excellent agreement, for to the seasoned pilot or operator no doubt exists as to the place weather occupies in the picture; all admit that it is the outstanding problem confronting safe flying operations to-day. Other problems which once seemed portentous, such as engine failure, structural failure, airport deficiencies, etc., while far from having reached their ultimate solution, have been coped with to a degree that has removed them from a position in the foreground. On the other hand, the factor of weather becomes more and more conspicuous. An official in one of the largest air transport companies in the West, after a year's operation, stated publicly that all the serious difficulties encountered by his company had been traceable directly or indirectly to the weather. Similar testimony could undoubtedly be offered by practically all air transport and air mail operators. It is a conclusion so obvious as to require no emphasis were it not for the unfortunate fact that certain enthusiasts in their efforts to promote public acceptance of aviation have circulated and encouraged the belief that the weather problem is no longer an obstacle to the safety

and regularity of flight. The apparently contradictory views thus engendered have led to widespread doubt and in some cases actual misconception in this regard.

To cite an illustration of how such misconceptions gain momentum, mention may be made of the assertion uttered frequently in the course of his public addresses by a pilot of national prominence, admirable conservatism and matchless skill, to the effect that "flying is now possible in almost any kind of weather." Certainly he has proved it so in his own case. But mark the terms he employed. He said it was *possible*; he did not say it was *safe*. This same pilot has abandoned his plane and descended by parachute four times in the course of his career as an aviator. Twice out of these four times it was weather that compelled him to jump—weather in which he found it *possible* to fly, but did not find it *safe*.

The personnel of an airways weather service should not ordinarily be governed by the consideration as to whether it is possible to fly, but whether it is safe. This is imperative where flying involves the transport of passengers; nothing should outweigh the injunction, "safety first." The degree of hazard, if any, may be weighed, and the question of relative safety decided accordingly; but decision should nearly always be on the basis of safety, and not the fortuitous one of possibility. The exceptions to this rule should only be allowed in the case of emergency flights which require the journey to be made even at considerable risk, such as in the movement of police forces or the dispatch of planes on other missions where public or private necessity supersedes the usual limits prescribed by caution. A larger margin of risk is conceded to the operations of the air mail, too, where such operations do not involve the transport of passengers. This distinction is commonly made by air-mail companies as a matter of course. It is not at all unusual for them to reject applications for passage, or even to cancel passage already sold, because of inimical weather conditions along the route, the plane, however, departing as usual but freighted only with the pilot and his cargo of mail. Here is a case of the operating company or pilot being governed by the consideration of whether the flight is possible or not, and disregarding, except in the matter of passengers, the question of safety. Even in the transport of mail, however, evidence points to the increasing conservatism being exercised by air mail contractors in the movement of mails alone. The loss of life may be limited to one—the pilot—but the loss of the ship is an expensive matter to the company, and the loss of important mails disastrous to air-mail patrons.

Before leaving the subject of weather in general as the predominating cause of airplane accidents, explanation is in order regarding the apparent contradiction this assertion may seem to invite from Department of Commerce statistics, which assign only 5 per cent of airplane accidents to this cause. The Department of Commerce bases its calculations on accidents contingent on all types of flying—student flying, practice flying, sport flying, professional flying, etc.—while the assertion which seems to be in conflict is intended to apply to one type alone, viz, professional flying or flying of the transport type. This latter type is deservedly in a class by itself and its casualty statistics should be segregated accordingly. Errors of piloting and mechanical difficulties, so preponderant as a source of accident in amateur or casual flying, are relatively insignificant in transport aviation; the pilots are men of ample experience and thorough training and the equipment usually of standard make and competently serviced. These precautions virtually eliminate from transport aviation the hazards so common to other types of flying and leave the weather factor predominant. It remains predominant for the obvious reason that the very nature of transport aviation makes it so; i. e., the attempt to fly regularly, day after day, or night after night, over a given route and maintain with as little interruption as practicable a prearranged schedule for the convenience of passengers and the transport of mails. Let any one recall the major accidents which occurred in flying of the transport type during the last year and it will be difficult to cite spontaneously any which were not directly attributable to weather. Memory, on the other hand, easily reverts to outstanding accidents that were so—the T. A. T. transport which was caught in a thundercloud over New Mexico and drifted into a mountain; the Maddux trimotor which was forced by descending ceiling to make a low-altitude turn in the darkness near Oceanside, Calif., scraping a wing in the maneuver with fatal results; the western air mail plane which went down a total loss in a snowstorm on a night flight between Salt Lake City and Los Angeles; the trimotor belonging to the same company which was caught in clouds over the mountains near Los Angeles and crashed in a canyon—these and perhaps other casualties spring to mind without effort, all of them directly attributable to weather.

The extent to which weather conditions affect the safety of flight being recognized, it becomes pertinent to inquire what are the particular forms of weather which introduce hazard and against which pilots and operators must be on guard. Concisely stated, these hazards are exactly two in number—fog and sleet. The term "fog," however, must be stretched to accommodate the airman's definition of it, which includes all cloud formations in which he may be immersed, or more broadly still, any atmospheric conditions which result in loss of vision.

It is easily understood and freely admitted that ground fog is a well-nigh insuperable obstacle to safe flying, because of the difficulty it introduces in landing and taking off. The merest tyro can understand the necessity of clear vision for the safe performance of either operation, especially the former. An experienced pilot can take a plane off the ground in a dense fog and fly by aid of instruments until the fog layer has been surmounted. Air-mail pilots call this "pulling the fog," and they occasionally do it to insure the transport of mails on schedule. It can not be classed with safe flying, however, for the reason that in case of motor failure, descent through the fog to a landing is almost certain to end in disaster. In other words, a take-off in the fog involves the possibility of a

blind landing, and blind landings are wholly without the pale of requirements demanded by safe flying.

The menace of sleet—a term in use among pilots to describe ice formations on the plane—is also well understood and freely admitted. No one with the slightest understanding of aerodynamics can be in doubt as to the hazard introduced by this phenomenon. Since a wing obtains its "lift" from the reaction of forces brought into play as the result of its passage through the air, such reaction being mainly induced by its peculiar shape and curvature, it is obvious that any deformation of the airfoil will impair and possibly destroy its function. Ice deposits produce such deformation, render the plane unmanageable, and in extreme cases make it incapable of sustentation. It is not, as some may suppose, the addition of an unwonted ice load that introduces danger, so much as the change in contour of the airfoil which ice coating brings about. Various schemes have been experimented with or suggested to combat this danger, but none of them has removed it. One plan proposes to heat the wings by various means; another suggests the use of wing-coatings of oil or wax on which ice will not collect; but nothing practical has evolved from either.

Ice may form on the ship when flying through freezing rain, but more often when flying through clouds composed of subcooled water droplets. The most dangerous temperatures are generally believed to be between 32° F. and 28° F., although Andrus states that the range may be much greater.¹ All agree that at present the only way of coping with ice is to avoid it. Says Andrus in the article referred to:

The ice problem is attracting widespread and expert attention. Its solution by many means has been proposed and devices and means are constantly being evolved by which the icing up of planes may be rendered harmless or impossible. The soundest means, that of avoidance, can not always be adopted, as conditions must be recognized well in advance to ensure avoiding those suitable for ice, and airplanes occasionally are caught unawares by sudden changes unanticipated. Nevertheless, avoidance is the best known method of reducing disasters in this field.

Bradley Jones says:²

Winter flying is hazardous. Cancelling trips under threatening weather conditions is a safety-first solution. * * * Oil or grease coatings are not always completely effective. Heating the wings should work out as the expense of reducing the plane's efficiency, but this solution has only been projected and not actually tried out. At present it is up to the pilot to keep out of the stratum of air wherein ice is liable to form.

That sleet and ground fog are very serious sources of weather hazard to aviation, perhaps the most serious, no one will deny; but they are by no means the only ones. As stated in the outset any atmospheric condition which precludes vision is a menace to safe flying; and our understanding of weather hazards must include those offered by cloud formations of any kind which are so disposed as to require the pilot to traverse them in the course of his journey. It is on this point—the dangers of cloud flying—that misconception is rife. Many suppose that it is as simple a matter to fly in clouds as to fly above or below them; others may imagine that the only obstacle offered by clouds is the difficulty of climbing through them to the region of good visibility above, and that once the cloud layer has been surmounted the rest will be plain sailing. It would surprise such individuals to know how seldom, relatively speaking, transport pilots do either in very stormy weather unless compelled to by circumstances.

¹ Meteorological Notes on the Formation of Ice on Aircraft, by C. G. Andrus, Monthly Weather Review, vol. 58, p. 22.

² Icy Wings, by Bradley Jones, U. S. Air Services, April, 1930, p. 24.

Of course flying above the clouds involves no hazard until it becomes necessary to descend, but that ultimate necessity may never be disregarded. Motor failure may require it at any time, but even if that contingency is waived, there remains the question of final descent at the airport of destination. The radiobeacon and radio communications may reduce the hazard for planes equipped to utilize such aids, but all planes are not so equipped, and even those that are must face the possibility of a blind landing should the radio broadcast inform them that the cloud level has lowered while they are in flight and now rests on the ground. Flying above storm clouds is to be shunned except under special conditions: First, because of the uncertainties of surface weather conditions (height of ceiling) in the event of a landing; second, because of dangers incidental to climbing through the cloud stratum if it is very deep and the possibility of not being able to surmount it at all; and third, because of navigational considerations. The first-named hazard is naturally at a maximum in cyclonic conditions and over mountainous country, and at a minimum over level country especially where stratiform cloudiness of relatively shallow type and adequate ceiling is involved. All three hazards are greatest at night and least by day. The following examples will suffice, although if space permitted they could easily be multiplied. Until recently when a new and relatively fog-free airport was secured in the Los Angeles area, the mail contractor whose duty it was to dispatch the northbound mail at midnight was seriously bothered by the canopy of so-called high fog which frequently formed over his airport during the late evening. Unless the ceiling formed in this way was quite high, say a thousand feet or more, the company would not risk a night flight through the cloud layer to the clear air above but would send the mail out of the area by automobile to the nearest fog-free field available, whence the remainder of the journey would be made by air. This fact was duly impressed on the airway-weather personnel as it was incumbent on them so far as possible to apprise the field manager of fog probability and allow him time enough to have a plane ready at a field outside the overcast area. Navigational difficulties incidental to flight above a cloud sheet were illustrated by Colonel Lindbergh's error in calculating his course to Mexico City, at the time of his famous nonstop flight there from Washington. The cloud layer below him prevented any check on his "drift" with the result that, although all things considered, his journey was a masterly exhibition of navigation by dead reckoning, he found himself considerably off his course when the sky finally cleared.

While flight above a cloud layer presents certain hazards, especially in rough country where the cloud sheet envelops or rests upon a mountain range and thus makes a crack-up almost certain in case of a "dead-stick" landing, it at present offers the only alternative to flying below the cloud stratum. Flying below the stratum is usually preferred; it enables the pilot to keep strictly on his course and if the course be along an established airway it will be well provided with intermediate landing fields on which emergency descent may be made. It may, furthermore, be provided with lights for his guidance by night. Flying below the clouds he has the choice, in case of a lowering ceiling, of "sitting down" or turning back. The same is true if snow, rain, or mist set in. Snow is very obstructive to visibility; rain much less so. However, in canyon flying the cloud level is likely to be

so low in the case of rain as to presage very dangerous conditions.

It has been said of mail pilots on the Pacific coast Airway that in bad weather they do not fly over the Siskiyou Mountains, but through them. They thread the tortuous passes, sometimes in weather so thick that the canyon walls are obscured on either side. Their method then is to weave from side to side of the canyon, swerving out of danger as the mountain wall looms on either hand. This can not be classed as safe flying, and on such occasions no passengers are carried. During part of the fire season in the Pacific Northwest last fall, a pall of smoke hung over large portions of the airway in western Oregon, and had much the same effect on flying operations that fog might have had. It will be remembered that for many days while the fires were at their worst, passengers were not carried on the transport lines in western Oregon as the condition of visibility made flying unsafe. Pilots had to fly by instruments alone until they were above the smoke layer, and face the threat of a blind landing at any time en route in case of motor failure.

This reference to flying by instruments brings up for consideration the concluding thought which it is desired to present for the contemplation of meteorologists who are serving the interests of aviation. It is a point on which there is considerable divergence of opinion within the flying fraternity itself, and the personnel of an airway weather service should understand thoroughly the nature of the problem and the occasion for the existing disagreement.

The term "instrument flying" is commonly used to denote the means employed by the pilot to keep his plane under control and on its course when view of the earth, sky, and horizon is obliterated. Other terms having substantially the same meaning in pilot's vernacular are "fog flying" or more often, "blind flying." Actually there is a distinction which should be drawn in the use of these expressions. "Fog flying" obviously refers to flying under a single kind of atmospheric condition only. "Blind flying" should not be confused with instrument flying, although this is frequently done, because, strictly speaking, "blind flying" is flying without vision and without the aid of instruments either.

Blind flying should never be attempted. It has been thoroughly proved in recent years that to fly "blind" without the aid of instruments is to invite disaster. Pilots who imagine they can fly blind for any length of time are altogether deluded, and there are very few who will push such a claim to-day, although in former years there were not a few who believed they could do it. In some cases they did and returned to tell the tale; but it was undoubtedly a case of the ship flying itself and the pilot having sense enough to let it. As a matter of fact neither the sense of direction nor the sense of equilibrium can be relied upon after the vision has been completely destroyed; the pilot can not tell except by instrumental means whether the ship is climbing, nosing down, banking, turning, or stalling. If in an open cockpit he can detect a skid or a slip by feeling the air strike him on one cheek or the other, but in a closed cabin this source of information is excluded, and except for his instrument board he has no warning of his peril. In former days the only instruments the pilot had to aid him in such an emergency were his compass, his air speed indicator, and his altimeter. If he was exceedingly careful his compass

kept him flying straight; his air speed indicator showed him whether he was maintaining flying speed or approaching a stall; his altimeter kept him informed of his height above his starting point. Once the ship got into a spin, however, his compass became useless and he had no instrumental means to guide him in the recovery of control.

In recent years important additions have been made to the foregoing equipment. Chief among these is the bank-and-turn indicator which shows the pilot whether he is turning or skidding and in what direction. The rate-of-climb indicator which shows him whether he is climbing or nosing down has also been brought out; the earth-inductor compass has been evolved; the radio direction finder and the capacity altimeter have been developed. All these aids have tended to make instrument flying more feasible, and may at first glance seem to have made it quite safe. This, however, is to assume a great deal too much. Indeed, it is upon this point that people within the industry are not wholly in agreement. Proponents of instrument flying point out that with so complete an instrument board, instrument flying is only a matter of training and practice. Most pilots, however, and notably those with years of flying experience, are loath to entrust themselves to it, and only do so when they have to and then for as short a time as possible. They point out with excellent reason the degree of concentration such flying demands, and say that to sustain it for any length of time is asking a good deal. Let us reenumerate the instruments that must be watched:

- Bank-and-turn indicator.
- Air speed indicator.
- Compass.
- Altimeter.
- Rate-of-climb indicator.

Of course one does not have to rivet his eyes on any but the first two, but from these he can scarcely let his vision stray for a moment. And such moments, when seized, must be long enough to allow a glance at not only the other instruments mentioned but at engine thermometers, oil and gasoline gauges, and tachometers. If he is depending on the radio beacon for navigation he is relieved of watching his compass; but if flying by compass he has a navigational problem added to that of merely flying the ship to harass him.

We know that men can do this sort of flying; some of them are doing it. How safely it can be done is a matter of debate. Some individuals are better qualified for it than others; unquestionably to do it properly requires a thorough understanding of the purpose and function of each instrument and continual practice in their use. Lieut. L. C. Ramsey, instructor in aerial navigation at the Pensacola Naval Air Station and a proponent of in-

strument flying, makes this statement in a recent and very illuminating contribution on the subject:³

It requires from three to six hours instruction or practice in this art before proficiency is gained. Some, with less aptitude for this kind of flying, require longer. Once confidence and proficiency are gained they must be maintained by frequent practice. Even a short lay-off results in a decrease in skill.

Dichman in his informative book, "This Aviation Business," expresses the following view:

To say that the problem is solved or nearly so is indicative of ignorance. Self-appointed heralds with only unbounded enthusiasm to guide them may announce that with the radiobeacon, induction compass, bank and turn indicator, radio phone to the ground, capacity altimeter, and other equipment the problems of safe fog flying are solved. However, men like Hegenberger and Doolittle, who are doing the pioneer work in this phase of aviation, will readily admit that there are still a great many problems to be solved before flying through a fog can really be considered safe and sure. (P. 145.)

Commander J. C. Hunsaker, vice president of the Goodyear-Zeppelin Corporation, in a very thoughtful paper on "Transoceanic Air Travel," presented at the recent national aeronautic meeting of the Society of Automotive Engineers summarized the situation in these words:

The effect of thick weather (rain, snow, fog) in inducing loss of control due to loss of visibility is extremely serious, although there is a general expectation that so-called "blind flying" by the use of instruments for control and radio for course and position will eventually overcome this hazard. To-day, we can only say that it is expected that in the future the airplane pilot will be independent of visibility. There will be, however, a necessity for special and delicate instruments, upon the correct functioning of which apparatus the lives of all on board will depend. Bearing in mind the inherent perversity of all delicate instruments, we must conclude that loss of visibility will continue to be dangerous for the airplane.

Discussion of this subject could easily and perhaps very profitably be extended, but the opinions offered should be sufficient to convince the airways meteorologist that for the present at least, and probably for some time to come, his greatest responsibility to the cause of air travel can be best discharged by alert and intelligent advice regarding atmospheric conditions likely to require blind flying, or flying by instrumental means alone. He should not be induced to minimize the cloud or fog hazard wherever safety of flight as distinguished from sheer practicability is the point to be considered, nor be misled by the abortive doctrine that "terminal weather" is the *fons et origo* of an airways weather service. On the contrary, he should apply to every part of the flying zone under his professional purview the purport of Clarence Chamberlain's recently broadcast ultimatum: "When I can't see, I don't fly."

³ The Distinction Between Blind Flying and Instrument Flying, by L. C. Ramsey, U. S. Air Services, April, 1930, p. 26.